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DISCUSSION OF RADAR ANTI-ANTIRADIATION MISSILE TECHNOLOGY--ALARMING PLUS DECOY SYSTEM

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Abstract. This paper briefly introduces the current development of antiradiation missiles (ARM) in overseas military circles, as well as some major tactic technical measures, taken in some countries in the area of anti-ARM threat air-defense radar. Also, it discusses the necessity, feasibility and key techniques of ARM threat alarming plus decoy arrangement, the effectiveness of deception type ARM decoy system and the significant role it plays in simplifying alarming equipment. Finally, it advances several basic ideas which are worth noticing in designing anti-ARM threat measures.

Key Words: antiradiation missile, threat alarming, radar bait, radar deception

1. ARM Threat and Its New Developments--Confronting Target Characteristics

In the early eighties, the United States successfully developed the AGM-88 high-speed antiradiation missile (HARM) and applied it on the Middle East battlefield, which marked that the development of the third generation antiradiation missiles was accomplished in some foreign countries. HARM, with its excellent properties including high speed, wide frequency band, high sensitivity and perfect signal processing, can produce a fatal threat to a missile guiding air-defense radar and even more seriously, it can impose a terrible psychological pressure on guidance radar operators, which proves to be even more disastrous than equipment loss.

Noticeably, there are two new developments of the ARM with cruise capabilities (such as the "Silent Rainbow"):

(1) With a single channel receiver of GPS, the global positioning system, the ARM is capable of correcting its course while in flight and delivering, through a sophisticated data transfer system, a target image acquired by the imaging seeker head onto the screen of a carrier aircraft, with which the pilot may select a target and strike a particular section of the target.

(2) Tremendous effort has been made to develop an ARM which can stay in air for a long time. Such ARM, once launched, can fly along a pre-programmed course and cruise at rest for a long time until an air-defense radar re-transmits a signal and launches an immediate attack, thus making the resistance to ARM through emergency "shut-down" ineffective.

2. Major Technical Anti-ARM Strategy by Using Air-defense Radars Adopted in Foreign Military Circles

2.1 Measures Taken by the Air-defense Radar Proper

(1) In the air domain, the main measure is to detect a target with narrow beams, and to decrease as much as possible the antenna parasitic lobe and back lobe levels, which is higher than 50dB at present.

(2) In the time domain, radiation power time control measures are taken, including waveform transmission with broad pulses, scintillation operation and emergency shut-down.

(3) In the frequency domain, measures taken involve frequency agility, pulse pressure, spread frequency technique, etc.

(4) Tactical measures of the distribution type, such as two-

base, multiple-base radar and C^3I are aimed at defending against ARM in terms of system engineering.

(5) Optical and electrical integration measures, i.e. integrating optical means closely with radars, which can resist not only ARM, but artificial radio jamming as well.

(6) A support system is widely set up in the radar to process ARM information, which can give a warning as soon as an ARM is detected, and control radar shut-down or take other anti-ARM measures.

2.2 Other Anti-ARM Measures Associated with Air-defense Radar

(1) Bait System

The bait system involves radio bait and its decoy system, infrared bait and its decoy system. The "Patriot" air-defense guidance radar is equipped with a decoy system, which is an independent transmission system, pointing at a target with the "Patriot" guidance radar in external synchronization. In this case, the carrier frequency and waveform of a transmitted signal are identical to those transmitted from an air-defense radar, and are positioned as much as possible within the ARM angular resolution range. Because of this device, ARM fails to distinguish the guidance radar from the decoy station in space, either mistakenly hitting the center of the connecting line between the guidance radar and decoy station or deviating to the latter.

The bait system "Witch" developed in Britain is a comprehensive decoy system which can transmit both radar bait and infrared bait, capable of dealing with an ARM seeker head of an unknown system or a composite seeker head.

(2) ARM Alarming System

Alarming as a precondition for taking any anti-ARM measures is attracting considerable attention in some foreign countries. For instance, the U. S. Air Force deployed a special ARM alarming system near the warning radar AN/TPS-43E, which can control radar shut-down immediately after an ARM is detected.

(3) Jamming System

Related techniques can be taken to jam an ARM seeker head and fuse, which can cause ARM hitting error to increase or the fuse to act ahead of time. The jamming system is usually used in combination with the alarming system; otherwise it may expose itself if it transmits too early, or lose its effect if it transmits too late. Real-time jamming transmission can sabotage the ARM and its platform exercising reconnaissance, location and accurate tracking of the air-defense radar.

Generally, the jamming system and decoy system have an integrated design and are used simultaneously. For instance, the French navy often applies a combination of the baits Dagaie and Sagaie together with a clutter interferometer.

(4) Hard Strike Measures

With telemetery data provided by the Patriot phase control array radar, the U. S. missile HAWK can intercept "air-to-ground" and "ground-to-ground" tactical missiles. The U.S. navy vessels strike ARM by employing the "Gattling" gun square array as the last line of defense.

Our discussion and analysis are centered on ARM alarming plus decoy technology as given in the following section.

3. Discussion and Analysis of ARM Alarming Plus Decoy Technology

3.1 Necessity of Developing an ARM Threat Alarming Device

This issue is raised because the ARM threat alarming device requires a large investment, complicated technology and long period to develop. Additionally, there is a dispute over whether or not it is necessary to construct such a device since under certain conditions, the air-defense radar itself can also accomplish the alarming mission.

ARM attack alarming is a prerequisite for any kind of counterattack.

In a medium- to low-altitude ground-to-air missile weapon system, the valid air domain of the search radar is at an azimuth 360° and pitch 0-27°, i.e. in three-dimensional space with an azimuth angle 360° and pitch angle 27-90°, the radar has an extremely large side lobe and has no ability to provide any detection and alarming.

In a medium- to high-altitude ground-to-air weapon system, the search radar, after searching and tracking an ARM platform, can only give an ARM attack alarming in $\beta\epsilon$=20°x20° air domain, while in other stereoscopic angles there is a large side lobe, vulnerable to ARM attack without detecting ability.

As far as the main station is concerned, its guidance radar also has no alarming ability in its solid angles beyond double its detectable air domain. Furthermore, it is difficult to reduce the side lobe of the radar's transmission antenna, while ARM has a great technical potential to receive the side lobe signal. With such a scenario, an ARM threat actually exists. The foregoing analysis indicates that this alarming device which is intended to compensate for the blindness of the guidance radar occupies a

significant position in ARM technology.

Furthermore, to resist artificial radio jamming and an ARM raid, the antenna parasitic lobe level of the air-defense radar has to be reduced as much as possible. Virtually, to reduce the parasitic lobe level of the transmission antenna is much more difficult than to reduce the parasitic lobe level of the receiving antenna, in which case ARM can easily make an attack through the parasitic lobe. Also, due to the extremely low parasitic lobe in the receiving antenna, it is very difficult for the guidance radar to detect an ARM with a very small radar section. However, it is easy for the special alarming device to detect an ARM using the main lobe.

There remains still the stealth technology issue in checking the fourth-generation ARM. Since ARM offers the best stealth effect in its nose cone direction, it can hardly be detected by any present single base radar even with the main lobe. On the other hand, the special alarming device can rather easily detect a stealth target while operating at a long wave frequency band, because with long waves, the stealth effect becomes very poor.

3.2 System Performance Required for An Alarming Device

3.2.1 General Requirements

(1) The working waveband of an alarming device is expected to be widely separated from the guidance waveband. The millimeter waveband is not advisable because it displays poor all-weather performance due to limitations of power and other factors. Meter or decimeter wavebands can cover a large air area and besides, their wavelength is comparable with ARM dimensions, which is favorable for increasing the reflecting section of a target.

(2) An active alarming device, which is likely to be attacked by ARM, costs much less than a guidance station, only one hundredth the price of the latter or even lower. Therefore, even if it is destroyed by ARM, the loss is limited.

(3) It has the capability of identifying an ARM, based on some ARM features such as speed, flight path directed at a target, its launch pattern, etc. An important factor of this system's reliable operation is to decrease the false alarm probability.

(4) It can be switched on and off through remote control without the need for operators, which leads to high reliability.

3.2.2 Technical Specifications

(1) Alarming distance: over 30km.

(2) Goniometric precision: $\Delta\beta = \pm 22.5° \sim \pm 45°; \Delta\varepsilon = \pm 15°; \Delta l = \pm 200m.$

(3) It has a standard database related to the reflecting section and fluctuation of a target, as well as the capability of identifying an ARM through screening.

(4) It has the capability of measuring the radial speed of a target and judging its flight direction (incoming or outgoing) with a precision limited to ARM identification.

3.2.3 Alarming Device Block Diagram

With an instantaneous omnidirectional monopulse alarming technique, this device can instantaneously accomplish rough measurements of the ARM direction, range, and speed resolution. With a fixed antenna and without a servo system, it operates as a fixed system to execute alarming with a quadrantal approximate goniometric measurement. Using a four antenna-system in this device is rather simple and requires the least equipment. Each antenna covers 90° with a 90° dip (neighboring beam axial lines). The axial line of the antenna and the connecting line between the

beam intersection point and the original point divide 360° into 8 rough azimuth regions with each region ranging 45°. The four antennas, respectively, are connected to a reception channel at their rear. The accurate value of the signal arrival angle is determined by the signal amplitude ratio from the neighboring channels. In each channel there is high amplification and a narrow band filter, which is designed to eliminate interference and raise sensitivity. Similarly, use of a crossed-field mixer and narrow band medium amplification is also aimed at increasing the operating range for which highly stable local oscillation is required. Logarithmic amplification is applied to change the amplitude ratio into a subtract operation, and the operational result stands for directional information, which is sent to the A/D converter for quantification and coding before being delivered to a digital information processor. This information can roughly guide the antenna of the decoy system to point at the ARM attack direction in the guidance radar blind region. The receiving and transmission antennas of the alarming system should be placed separately.

3.3 Analytical Calculations of the Major Parameters of the Alarming Device

3.3.1 Alarming Distance Estimate

R=44km (the calculation process is omitted here)

3.3.2 Amplitude Ratio Calculations

Fundamental analysis suggests that the amplitude ratio from neighboring channel signals represents the information concerning the accurate azimuth of a target. When a wide band helical antenna is adopted, Gaussian function can be used to approximately describe its radiation pattern. Experiment shows that the helical antenna has a signal-receiving power as follows:

$$P = \exp\left(-k\left(\frac{\varphi}{\theta_0}\right)^2\right) \qquad (1)$$

where φ is the included angle between arrival direction and beam axial line

θ_0 is the width of a half-wave lobe, i.e. $0.5\theta_{0.5}$
k is ratio constant.

Fig. 1 is the radiation pattern of the 90° four-antenna system.

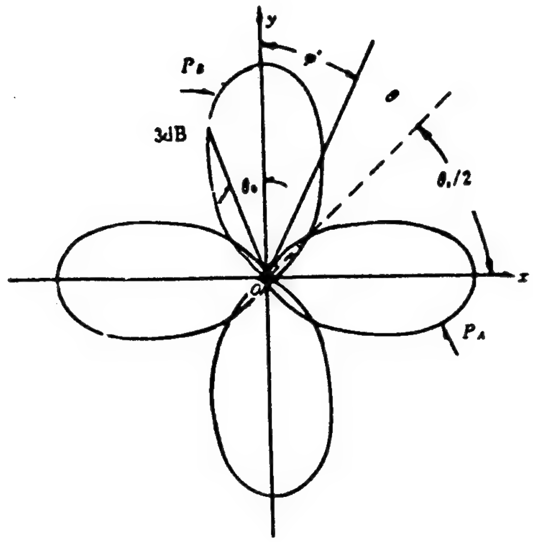

Fig. 1. Four-beam Gaussian-shaped Radiation pattern

It is known from Eq. (1) that the signal power received by two neighboring antennas, respectively, are

$$P_A=\exp\left[-k\left(\frac{\theta_0/2+\theta}{\theta_0}\right)^2\right],$$

$$P_B=\exp\left[-k\left(\frac{\theta_0/2-\theta}{\theta_0}\right)^2\right]$$

Given a logarithmic power ratio

$$R'=10\lg\frac{P_B}{P_A}=\frac{10k\lg e}{\theta_0^2}2\theta\theta_0$$

we obtain

$$\theta=\frac{\theta_0^2R'}{20k\theta_0\lg e} \qquad (2)$$

When $\phi=\theta_{0.5}/2=\theta_0$, the receiving power decreases by 3dB, therefore when $\exp(-k)=1/2$, we obtain $k=0.693$, which is then substituted in Eq. (2) for simplification as

$$\theta=\frac{\theta_0^2}{6\theta_0}R' \qquad (3)$$

By substituting $\theta_0=\theta_{0.5}/2$ into (3), we obtain

$$\theta = \frac{\theta_{0.5}^2 R'}{48(\theta_1/2)} \tag{4}$$

Obviously, when $\theta_{0.5}$ and θ_1 are held constant, the arrival angle θ is directly proportional to power ratio R', i.e. its system error does not change with azimuth angle and also, the slope (dB) in beam radiation pattern remains unchanged within θ_0; when $\theta_{0.5}=90°$, 1dB channel imbalance may cause the Gaussian system to generate a 3.75° peak error.

3.3.3 Analysis on System Errors and Random Errors

The expression of total goniometric error peak value is Eq. (4), and it is solved through differentiation as:

$$d\theta = \frac{\theta_{0.5}}{12\theta_1} R' d\theta_{0.5} - \frac{\theta_{0.5}}{24} R' \frac{\Delta\theta_1}{\theta_1^2} + \frac{\theta_{0.5}^2}{24\theta_1} \Delta R' \tag{5}$$

It can be seen from the foregoing equation that any variation of $\theta_{0.5}$ $\Delta\theta$ and $\Delta R'$ may lead to goniometric errors. Our discussion first goes to system errors:

(1) To resist interference and meet the need of harmonic oscillation in different sections of a target, a f=150-300MHz wide frequency band antenna is supposed to be used in our arrangement, with which $\theta_{0.5}$ will inevitably change with the change of f_0. Similarly, polarization of θ_0 and axial ratio will also change with the change of f_0, causing channel imbalance and goniometric errors.

(2) The insertion loss of the microwave filter in the receiver becomes inconsistent with the change of frequency and temperature; the gain of the low-noise radio frequency amplifier may change ±1.5dB because of the difference of f_0; the video frequency can also cause an imbalance among different channels, such as a change in logarithmic amplifier gain characteristics with changes in input

level and environmental temperature.

Generally, the typical angular error of the four-antenna goniometric system has a mean square root value of 10-12°, out of which 3-4° is due to the antenna, while 5-2.5° is due to 1dB circuit imbalance.

As far as random errors are concerned, they are mainly caused by the internal noise of the goniometric system. Specifically, since internal noises from neighboring channels are unrelated to one another, they cannot compensate for each other during amplitude ratio calculation, thus leading to a channel imbalance to produce goniometric errors. The foregoing analysis suggests that the slope appears rather large and so does the goniometric error caused by the unit channel imbalance at the beam intersection point. Therefore, our analysis is focused on random errors at this intersection point (as shown in Fig. 2).

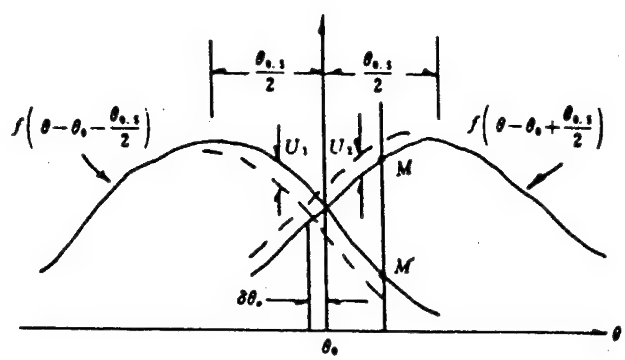

Fig. 2 Effect of Noise on Intersection Point Location

Two neighboring wave lobe radiation patterns can be expressed, respectively, as $f(\theta-\theta_0-\theta_{0.5}/2)$ and $f(\theta-\theta_0+\theta_{0.5}/2)$, where θ_0 is the azimuth angle of the intersection point. When there is no noise, the backward wave is located at θ_0, the amplitude ratio is 1, i.e.

$Af(-\theta_{0.5}/2)-Af(\theta_{0.5}/2)=0$.

When there is noise, the radiation pattern undergoes a displacement as indicated by dotted lines in the figure. The actual direction of the intersection point deviating from the radiation source is $\delta\theta_0$, and the angle measured is $\theta_0+\delta\theta_0$. In this case, the identical conditions can be expressed as

$$Af[(-\theta_{0.5}/2)-\delta\theta_0]+U_1-Af[(\theta_{0.5}/2)-\delta\theta_0]-U_2 \quad (6)$$

where A is the maximum signal voltage; U_1, U_2, respectively, are noise voltages of two neighboring signal channels.

By expanding the radiation pattern function into a Taylor series at the intersection point without noise up to the binary derivative term, Eq. (6) will change into:

$$Af(-\theta_{0.5}/2)-A\delta\theta_0 f'(-\theta_{0.5}/2)+A\delta^2(\theta_0/2)f''(-\theta_{0.5}/2)+U_1-Af(\theta_{0.5}/2)$$
$$+A\delta\theta_0 f'(\theta_{0.5}/2)-A\delta^2(\theta_0/2)f''(\theta_{0.5}/2)-U_2=0$$

As $f(-\theta_{0.5}/2)-f(\theta_{0.5}/2)=0$, and the radiation pattern function is symmetric, which will come to zero if subtracted by the corresponding even number term.
i.e. $f''(-\theta_{0.5}/2)-f''(\theta_{0.5}/2)=0$; the odd term is $\delta\theta_0 f'(-\theta_{0.5}/2)=\delta\theta_0 f'(\theta_{0.5}/2)$
Thus, the random goniometric error can be derived as

$$\delta\theta_0=(U_2-U_1)/[2Af'(\theta_{0.5}/2)]$$

The mean values of U_1 and U_2 are zero with identical variances, while $Af(\theta_{0.5}/2)$ can be replaced by $A/\theta_{0.5}$. Thus, θ_0 can be solved as

$$\sigma\theta_0=\sigma_n\theta_{0.5}/(2^{\frac{1}{2}}A)=\theta_{0.5}/[2^{\frac{1}{2}}(S/N)^{\frac{1}{2}}] \quad (7)$$

Equation (7) indicates that the mean square root of a random error $\sigma\theta_0$ is in direct proportion to $\theta_{0.5}$ and in inverse proportion to S/N. When S/N is very low, goniometric precision will decrease.

3.3.4 Determination of Dip and Beam Width

From Eq. (3), the following can be derived:

$$\frac{d\theta}{dR'} = \frac{\theta_0^2}{6\theta_s} = \frac{\theta_{0.5}^2}{24\theta_s} \tag{8}$$

From Eq. (8), $d\theta/dR'$-$\theta_{0.5}$ curve can be drawn as shown in Fig. 3.

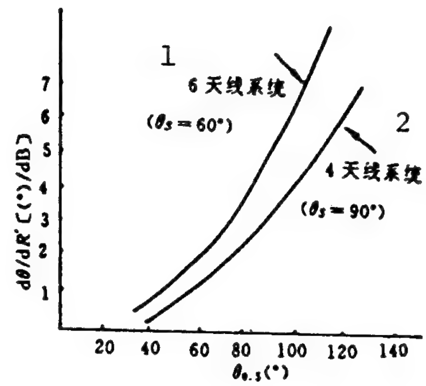

Fig. 3 Relationship between Peak Value Deviation Caused by Change of Unit Power Ratio and Beam Width

Key: 1. 6-antenna system; 2. 4-antenna system

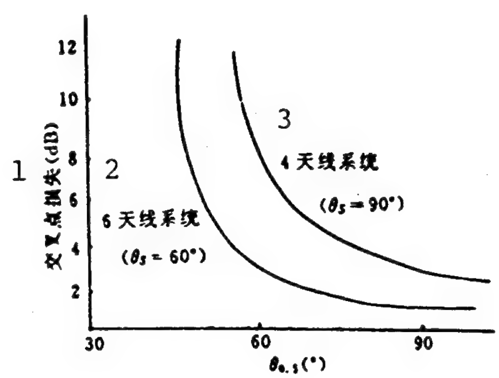

Fig. 4 Relationship Between Intersection Point Loss and $\theta_{0.6}$

Key: 1. Intersection point loss;
2. 6-antenna system;

3. 4-antenna system

From the foregoing curve, the peak value deviation caused by 1dB imbalance among different channels under different beam widths can be calculated. In the four-antenna system, 1dB imbalance can give rise to a peak deviation angle 3.75°, while in the six antenna system, the peak deviation is 5.6° when $\theta_{0.5}$ still remains 90°. If $\theta_{0.5}$=60° is given, the six-antenna unit imbalance will cause a peak deviation angle 2.5°. It is known then that $\theta_{0.5}$ should be equal to $\theta_{\cdot}$.

Equation (3) indicates that the power ratio of neighboring antennas in receiving the same signal is in inverse proportion to $\theta^2_{0.5}$. Based on this, taking 3dB intersection point as a basis, dB number of the neighboring two antennas radiation pattern ratio at a deviation angle $\dot{\varphi}$ of radiation source from antenna axial line can be estimated as:

$$R' = 3(\dot{\varphi}/\varphi_0)\mathrm{dB} \tag{9}$$

where ϕ_0 is the included angle between the connecting line of beam intersection point and original point, and the beam axial line.

As for the four-antenna system, if $\theta_{0.5}=90^0$, then $\varphi_0=45^0$, and the loss at that intersection point can be calculated in accordance with the foregoing equation as $L=R'=3(45^0/45^0)^2=3$dB. And when $\varphi''=90^0$, then $R''=3(90^0/45^0)^2=12$dB, which is the maximum depth (zero depth) of the differential radiation pattern of that antenna. This relational expression can be used to estimate the intersection point loss of different $\theta_{0.5}$ under a given $\theta_{,}$. Fig. 4 shows the relationship between intersection point loss and $\theta_{,}$ under a given $\theta_{0.5}$. It can be seen from the figure that if intersection point loss is 3dB, the antenna $\theta_{0.5}$ should be equal to $\theta_{,}$. Under such scenario, if goniometric precision is to be increased, $\theta_{0.5}$ must be made narrow at the expense of the sensitivity at the intersection point.

3.4 Key Techniques of Alarming Device and Their Solutions

3.4.1 Once a lower frequency band is adopted, the key issue is that high requirements should not be encouraged for goniometric precision except when a large-scale antenna is applied, and a large antenna will certainly increase the complexity of the entire AARM system as well as its cost. To solve this problem, a cheating type decoy system is created in our alarming--decoy design.

3.4.2 To simplify the equipment, a four antenna system is applied to the alarming receiver with a very wide and low gain. In addition, the receiver is subject to low noise amplification and narrow band medium amplification so as to ensure an ARM alarming distance. This requires that the local oscillation frequency stability should not be lower than 10^{-5}. On the other hand, to acquire Duppler information, the local oscillation frequency stability should not be lower than 10^{-7}.

3.4.3 To realize instantaneous omnidirectional goniometry and equipment minimization, an eight antenna transmission system and four antenna receiving system are adopted and also, single pulse processing is used to obtain directional information. In such case, when the arrival angle is located at M, M' point in Fig. 2, the signal level in one of the signal channels is above six times limit(M), while the other is possibly under threshold (M'), meaning that the amplitude ratio value cannot be acquired, and ratio amplitude direction measurement cannot be realized. To solve this problem, the major practice is, apart from raising receiver sensitivity, to hold the target at the harmonic oscillation frequency. Therefore, for different targets, transmission carrier frequency is required to adjust conveniently and automatically within the range from 10MHz to 300MHz. At the same time, the speed and separation of the high-power coaxial switch of the transmission system should be taken care of.

3.5 How to Realize Reliable Deviation Guidance under Rough Alarming

3.5.1 Special Requirements from ARM Receiver for Arrival Time of Signals Transmitted by Target Radar and Decoy System

To overcome seeker head guidance system confusion caused by multi-path and multi-target interference, a "pulse leading-edge selected" circuit is generally set up in ARM to switch off receiver after target radar is at 0.1μs, and filter out non-target signals. The most conservative practice is to make the time of decoy radiation signal arriving at the outlet surface of ARM antenna coincide with the arrival time of guidance radar signal (with the permitted error 0.1μs). This arrival time difference is a function of the included angle between antenna axial lines of ARM and decoy system, which varies at any time with ARM arrival, and it varies to different degrees with the ARM arrival direction. Calculations show that the time difference between two arriving pulses can be objectively corrected to within 0.1μs with a computer only when the guidance station or alarming device can reach an extremely high precision in ARM three coordinate testing. Apparently, the approximate alarming guidance system lags far behind this requirement, otherwise a high price has to be paid for the complexity and cost of the alarming device.

3.5.2 Effective Measures for Arrival Time Coincidence

One method is that the decoy pulse guides the guidance radar pulse transmission in advance all the time. The second method is that the decoy system transmits a clutter interference to confuse an ARM seeker head. With the first method, the system may easily be recognized since time difference varies with the passage of time. Similarly, with the second method, the system may be exposed even more, and the power capacity of the deviation guidance transmitter may be heavily loaded. However, there is a third method which, as an automatic guidance device, can hardly be identified and can be easily realized, appears more clever. Such

a cheating type decoy source, which can provide answering interference, proves to be of universal value as suggested by an analysis on Phoenix and sophisticated passive reconnaissance systems.

3.5.3 Requirements for Antenna Beams of Decoy Device

(1) To let a guidance radar or search radar posses ARM three coordinate detection capabilities in the valid detectable space domain of a weapon system, the decoy device should be equipped with an antenna of high gain and narrow beam, with its pointing direction being in external synchronization with either a guidance radar or search radar. This procedure is aimed to realize a roughly identical power level of both the decoy pulse and search pulse at the outlet surface of the ARM antenna.

(2) In the side lobe blind region of the protected radar, the deviation guidance system provides azimuth and elevation angle information through rough alarming transmitted with wide beams. Suppose it can cover an air domain 60^0x30^0, then its antenna gain will decrease by 17dB compared with a (6^0x6^0) antenna. Thereby, the foregoing identical power level of both pulses can be ensured in the side lobe region.

3.5.4 Estimate of Transmitter Power of Decoy System

As an ARM can hardly keep tracking over the main lobe of the guidance radar antenna and the parasitic lobe can provide only an extremely low level, a better decoy effect is secured if the transmission power level of the decoy system is 15-20dB lower than that of the guidance radar. To ensure the safety of a guidance radar, the transmission power of the decoy system should be designed no lower than that of the guidance radar.

3.5.5 Layout of Decoy System

(1) Distance arrangement
Based on calculations over many factors, including restriction of the resolution angle of an ARM seeker head, safe distance determined by ARM kill radius, etc., the distance between the decoy system and protected radar is designed as 150-500m.

(2) Distribution array and quantity
The simplest arrangement is a uniform square array with the protected radar as center, which is surrounded by four decoy systems aligned evenly. Another desirable arrangement is "single-line array", i.e. two sets of decoy systems are arranged respectively on both sides of the protected radar, which can formulate a relay decoy system with high flexibility and a high safety coefficient.

(3) Working Principle and Effect of Relay Decoy System
The relay decoy system consists of a protected radar A and decoy systems B and C. This system, upon receiving an alarm signal, starts the cheating pulse series in pre-programmed procedures and increases its transmission power level in the order of A--B--C (in fact, this weakens the power level of the former), thus guiding ARM away from A and relatively increasing its safety coefficient. The key parameters of the relay decoy is the selection of d_1 and d_2 as well as the control moment of transmission power level.

3.6 Major Characteristics of Alarming--Decoy Arrangement

(1) The protected radar can continue combating without being shut down under ARM attack. It can choose from the following three operations: one is forming a "scintillation temptation" system together with a decoy device as is done with "Patriot"; another is that the protected radar keeps "silent" with transmission done by

the decoy device instead; still another is formulating a relay decoy system.

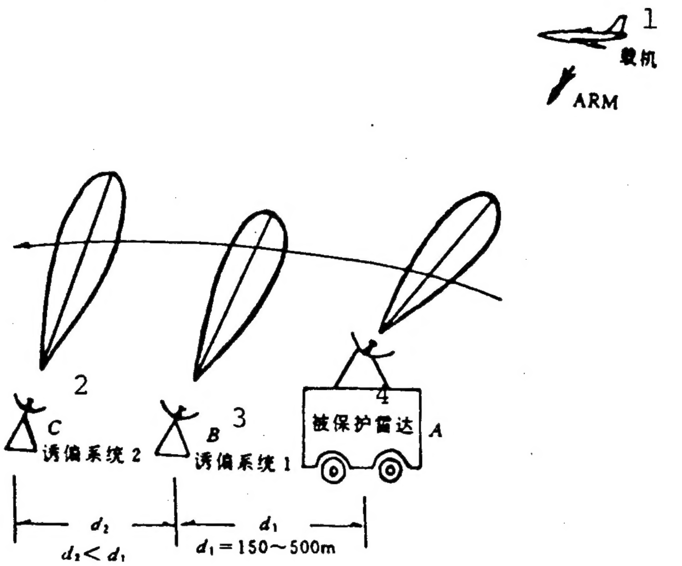

Fig. 5 Layout of Relay Decoy System

Key: 1. Carrier aircraft; 2. Decoy system 2; 3. Decoy system 1; 4 Protected radar

(2) It has a high safety coefficient. As this system can compensate for the alarming blind region of the guidance radar, provide reliable and effective decoy and operate flexibly, the safety coefficient of the protected radar and decoy systems themselves can increase to a great extent.

(3) This system is simple, cost effective, suitable for our country's conditions. Therefore, it can be widely spread in use.

(4) With our arrangement, the system discussed in this paper can deal with the threat from the fourth generation ARM, such as imaging system, by using "Carpet" technology as an extended function.

4. Several Basic Ideas concerning ARM Threat Resistance

4.1 Fail Safe

ARM is a hard kill means with an extremely high percentage of hits. Therefore, whether or not an air-defense radar can effectively defend against an ARM threat becomes a problem of life or death. This requires that any air-defense radar anti-ARM technical measure be extremely effective and fail safe. To accomplish this goal, it is almost impossible to rely on a single technical measure; instead, it is necessary to take a number of measures, based on joint efforts with all related departments, specializing in their respective specialties.

4.2 Overall Consideration and Integrated Solution

Since ARM threat resistance is closely associated with interference and anti-interference, anti-concealment as well as air-defense networks arrangement and their tactic applications, overall consideration of various factors is necessary in working out any scheme in this area so as to get twice the result with half the effort.

4.3 Our Aim of Goal at the Third Generation and Fourth Generation ARM

To meet the needs of future air defense operations, the anti-ARM threat scheme must be formulated on a high starting point and

at an advanced level, such as pointing its aim at the third and fourth generation ARMs.

4.4 Synchronous Development and Mutual Promotion

ARM threat and anti-ARM threat are a pair of contradictions. It is correct to take anti- ARM threat as a focus in terms of national territory air defense. However, without ARM development with appropriate manpower and material, it would be hard to reach the goal of perfectly safe in anti-ARM missions, just like the mutually complementing relationship between interference and anti-interference. As a minimum requirement, an ARM simulator is expected to be developed to check up with the quality of AARM work.

4.5 Giving Consideration to Both Near-term and Future Needs

Our near-term goal is to take HARM as a major target, while the long-term goal is the radioactive and passive, radio and optical (infrared, laser, television) composite seeker heads, and long distance cruise ARM. Such arrangement is based on an advanced starting point and at the same time, on our actual conditions including our technical void and financial situation.

Based on an analysis on the existing and planned technical options, a two level program has been worked out. With well developed technologies, the first level is centered on solving the anti-ARM (mainly HARM) issue with existing radars. The second level is intended to resist the threat from the third and fourth generation ARMs by using air-defense radars and with more sophisticated techniques before and after 2000. Both two levels will start simultaneously in such a relationship that the first level is aimed to lay a solid foundation for the second level and also includes some needs of the latter, while the second level advances a more ambitious goal with more advanced technologies, which is scheduled to be accomplished in a longer time. In

addition, the second level can take in some useful experience and mature technologies acquired in the first level. On the other hand, some advanced research technologies developed in the second level can be applied and tested in the first level. In other words, our program is based on mutual promotion, and consideration of both near-term and future needs.

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